International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 8 Issue 10 Series. I || October 2019 || PP 08-14

Analysis of a Single Shorted Rectangular Microstrip Antennafor 50Ω Microstrip Line Feed

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Abstract: *In this paper, analysis of a lower order and dominant mode of a rectangular microstrip antenna with a loading of the single shorting post has been presented. Microstriplinefeedof50Ωimpedance alongone ofthe radiatingedgeswith a single shorting posthasbeenproposedforimpedancematching. A detailedinvestigationofthe rectangularmicrostripantennawith and without single shorting pin has been presented and experimentallyvalidatedwith good agreement.*

Keywords -*Fundamentalmode, lowermode,microstrip antenna, shorting post.*

Date of Submission: 01-10-2019 Date of acceptance: 16-10-2019

I. Introduction

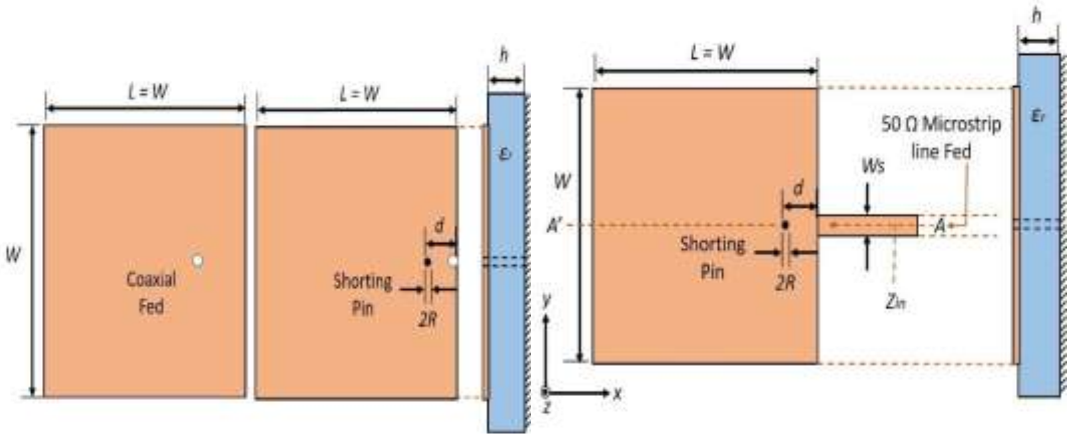
Inrecentyears,compactantennahasreceivedmuchattentionduetotheirsmallersize,asconventionalantennashavesizetoolargethatdonotfitinsidewirelesssystemsorpersonalcommunicationsystems.Inaddition,theattractivefeaturesoflowcost,lightweight,lowprofileandeaseoffabrication makesshortedmicrostrip antennas(MSA)asagoodchoice overotherantennas[1].AMSAcanbeeasilyintegratedwith activedevicesandmicrowave integrated circuitsby properlychoosingdirectfeedingtechniquesofmicrostripline[12].InputimpedanceandcharacteristicsoftheMSAaregenerally influencedby thefeeding technique, soitisacrucialantenna designparameter.Inorder tomakea totalantennastructureto beplanar,feedingarrangements such asedgefedand microstrip fedcanbeetchedonthesamesubstratelayer.A MSAhaveahighinputimpedance atradiating edge,which causesdifficulty inimpedancematching.Detailed investigationtosolvetheinputimpedanceofanedgefedMSA iscarried outwiththehelpofthecosinefunction in[3].In alternativemethodofinsetfed,inputimpedanceissensitiveto notchwidth anddepthwhichleadstoincreaseinthecross- polarizationlevelinH-planeasthepatchgeometriesbecomes asymmetrical[4].

Compactandshortedconfigurationsofrectangular,circular andtriangularantennaswiththeshortingpost/pintechnique havebeenreportedintheliterature[1,5-8].Shortingplatesor shorting postsalongthezerofieldlineofthefundamental modehelptorealizecompactmicrostripantenna[7].Recently, in[9]impedanceagilerectangularmicrostripantenna(RMSA) loadedwithsingleshortingpininsidethepatchisproposed. The shorting helps to reduce the input impedanceof theradiatingedgeofMSAandfacilitatingamicrostripfeedofcharacteristicimpedanceof110Ω.Generally,microstriplineof110Ωimpedanceisnotused,insteada50Ωtofeedlineisoftenpreferredsothatitiseasilyintegratedwithmicrowavecircuit. Furthermore,theshortingalsointroduceslowermode frequency besidesaltering dominantmodes,whichhasnot beendiscussedinthepaper[9].

Inthispaper,detailedinvestigationoflowerordermodeand thedominantmodefrequencyofaRMSA withsingleshorted postand50Ωmicrostriplinefeedalongtheradiating edgeis presentedandresultsare validatedusingexperiments.

II. Antenna Configuration

A RMSA has been designed at the fundamental mode frequency (TM10=FF) of 1.56 GHz with dielectric substrate
R04003C having a relative permittivity of ω = 3.55, a dielectric thickness of h= 1.524 mm and loss tangent tanδ=
0.0027. The length and width of L=W=50 mm are calculated using the formulations given in [1].



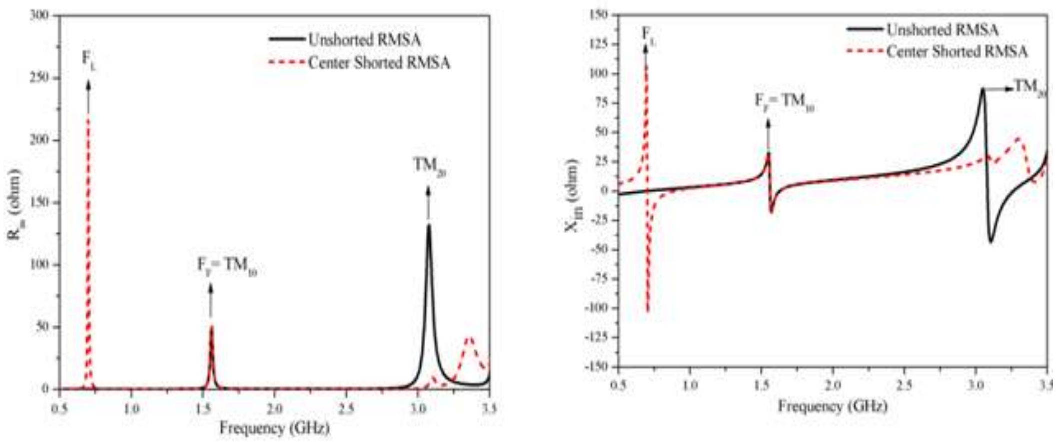
a) b) c)

Fig.1. Geometryof RMSAa) Coaxial fed,b)End Coaxial fedshorted and c) ShortedRMSAfedalong radiatingedge

III. Antenna Analysis

A. Modalanalysisofbasicco-axialfedRMSA

ForthefundamentalTM10modethecenterofthepatchhaszeropotential.Thus,byputtingashortatthecenterthecharacter isticofTM10 modedoesnotalter. However,itintroducestheadditionallowerorder mode.



a) b)

Fig. **2.** Simulated results of co-axial fed RMSA with and without center shorting post (a) Input resistance and (b) Input reactance

Fig.2(a)and(b)depictsthesimulatedinputresistance(R_{in})andreactance(X_{in})resultsofacoaxialfedRMSAwith andwithoutacentershorting post. The 50Ωco-axial feed positionwasdeterminedas7.35mmfrom thecenter.ItisconfirmedfromFig.2that,ifRMSAisshortedatcenterd/w=0.5)viatheshortingpostofradiusR=0.5mm,producesthelowerordermodefrequency(F_L)whilethefundamentalmodefrequency(F_F)remainsunaltered.$F_L$correspondsto the condition thatthelengthfromshortingpointtotheopposite corneralongtheradiatingedgeoftheRMSA isλ/4.Thereis slightincreaseinhigherordermodefrequency(TM_{20})dueto theshortingpostatcenter.

B. Investigation of shorting position verses F_L and F_F

AnendcoaxialfedRMSAwithshorting postsfor50Ω match isshowninFig.2(b).ToanalysetheeffectonF$_L$and $F_F$simulationhasperformedwithpositionoftheshortingpostd/w.TableIgivesthevariationof$F_L$and$F_F$ofshortedRMSA withdifferentshorting postposition (d/w).Fig.3depictsthe sameeffectgraphically. Ithasbeenobservedthatwithan increaseind/wfrom 0to0.5,$F_F$isincreaseswhileF_L decreases.Thefeed pointhas to belocatedcloserto the shorting postforimpedancematching.Themaximumreductioninthe$F_F$isobtainedwhentheshortingpostisplacedatradiatingedgeoftheRMSA[1,8].Forfundamental TM_{10} modevoltagedistribution variesfrom zeroatcentershort location(d/w=0.5)toamaximumvalueattheedge(d/w=0.05)oftheRMSA.Theresonancefrequency $F_L$atcenteris approximately calculatedbyequating$L_e/2+W_e/2=\lambda/4$. Resonancefrequency$F_L$formulationofsingleshortedRMSA isreportedin[1,8].Whenshortingpostalong thecenterline movesfromedgetothecenter, effectiveL_e(whichisalength fromshortingposttothecorneroftheoppositeradiatingedge) decreasesmakingL_e +W_e/2shorter,ThustheF_L decreases. Fig.4comparessimulatedandcalculatedfrequency (F_L)for different d/wratio. Theincrease in$F_F$withincreaseind/wisbecauseofmodificationoffielddistributioncausedbytheshortingpostanditdoesnotremainpureTM_{10}mode.

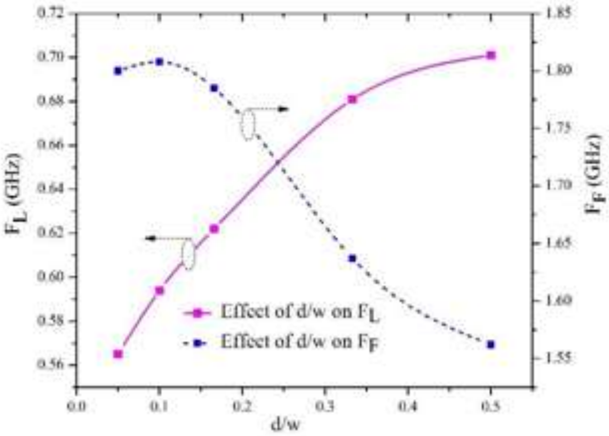


Fig. 3. Effectof position d/wof shortingpositionon$F_L$andF_F

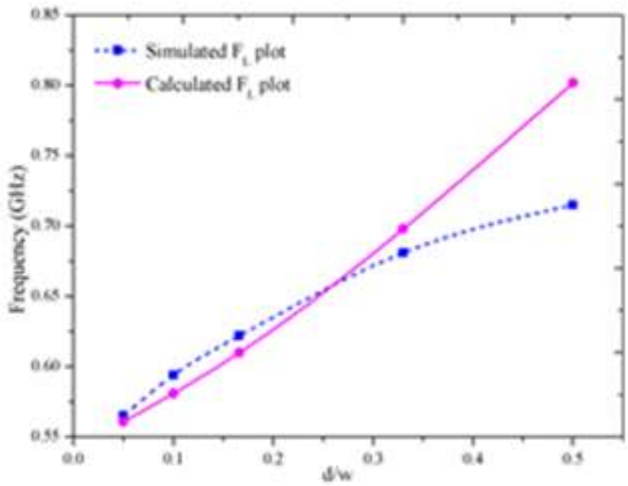


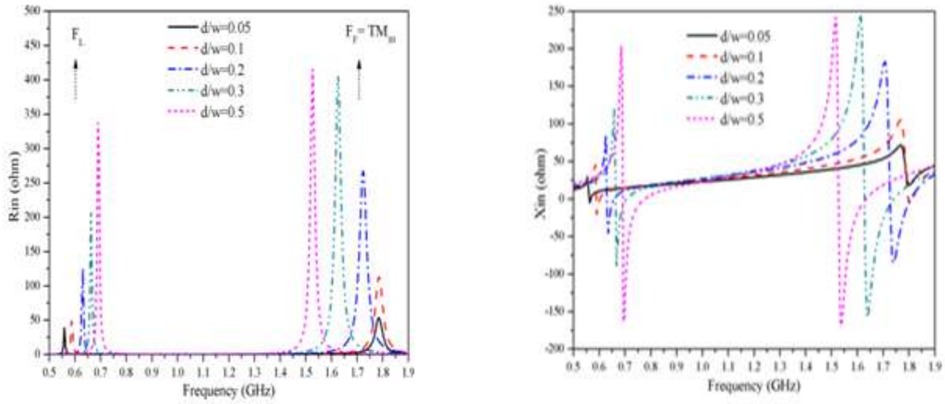
Fig.4. Comparison plot for simulated and calculated F_L with different d/w ratio

TABLE I. VARIATION OF F_L AND F_F WITH DIFFERENT SHORTING POSITION

Sr.No.	Configuration (Freq.in GHz)	F_L	F_F
1	Un-shortedSimpleRMSA	-	1.560
2	Center ShortRMSA(d/w=1/20	0.701	1.562
3	Shorted(d/w=1/3)	0.681	1.6379
4	Shorted(d/w=1/6)	0.622	1.785
5	Shorted(d/w=1/10)	0.594	1.808
6	Shorted(d/w=1/20)	0.565	1.800

C. SinglepostloadedRMSA with50ΩMicrostripline feed atradiatingedge

Fig.1c)depicts the50Ωmicrostrip linefeedalong radiating edgeofshortedRMSA. Themicrostripline dimensionareW_S=3.402mmandL_S=10mmwiththesingle shortingpostofradiusR=0.5mm,introducedalongthecenter lineAA′.Dueto theshortingpost,a surfacecurrentdensityat thatlocationgetsstrengthen, whichhelpstoreducetheedge impedance oftheRMSA. Fig.5(a)and(b)depicttheinput resistanceandreactance,respectively,of 50Ωmicrostripline feedalongradiatingedgeofshortedRMSAwithdifferentd/w ratio.Itisobservedthatasd/w ratioincreases(pinmoves towardsthecenterfrom radiating edge)i.e.d/w=0.05to0.5, theinputimpedanceof$F_F$and$F_L$reducedfrom420Ωto 50Ω and330Ω to46Ω,respectively.



a) b)

Fig. 5. Simulatedresultsof50Ωmicrostripline fedshortedRMSA with differentd/wratio (a)Inputresistanceand(b) Input reactance

TheresonancefrequencyofFFisincreasedfrom1.56GHzto1.793GHzwhileFLisdecreasedfrom0.7GHzto0. 55GHz.Hence,bychoosingtheproperpositionofashortingpostwiderangeofinputimpedanceofmicrostripedgefedRMSAcanbeadjustedforvariousfrequency.Theproposedapproachof50ΩmicrostriplinefeedRMSAeliminates theuseofseparate TRLcalibrationkit,whichisproposedin[9]forde-embedding therealinput impedance. Fig.6depictsthesimulatedco-polarizationinE-planeandcross-polarizationinH-planeofthe50ΩmicrostriplineedgefedRMSAwithdifferentd/wratio.

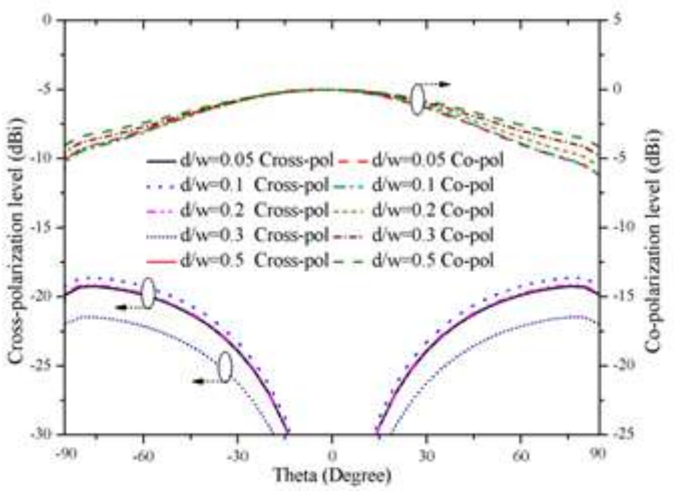


Fig. 6. Co-polarizationinE-planeand cross-polarizationinH-plane of the 50Ωmicrostriplineedge fedantennawith different d/wratio

Duetoauseof 50Ωmicrostrip linefeedcross-polarization levelinH-planeisreducedtomorethan-20dBforallcasesof d/w pinratioasshownFig.6,whichismarkedimprovement ascomparedtoresultsproposedintheliterature[9].

IV. Result And Discussion

Tovalidatetheproposeddesignofradiatingedgemicrostrip linefedconfiguration, two50ΩmicrostripedgefedRMSA withandwithoutshortingpinarefabricatedasshowninFig.7andmeasurementarecarriedoutusingAnritsuvectornetwork analyzeronsubstrateRO4003C having patch dimensionof50 x50mm^2.Theshorting postislocated atd/w=0.1with50Ω microstripline ofW_S= 3.402mmandL_S=10mm. Theground planedimension was70x70mm^2.Fig.8depictsthesurfacecurrentdistributionofmicrostripedgefedsingleshortedRMSAatcorrespondin g$F_L$andF_F.Allthesimulationhasbeenobtainedbyusingthemethodofmomentsbasedsoftwarel E3D withinfiniteground plane[10]. Thesimulated andmeasured resultarecomparedFigs.9and10.

a) b)

Fig.7. FabricatedmicrostripedgefedRMSAantennaa)Withoutshortingpin andb) Withshorting Pin

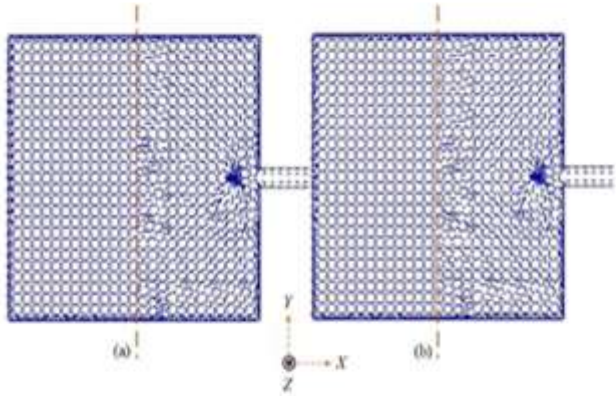
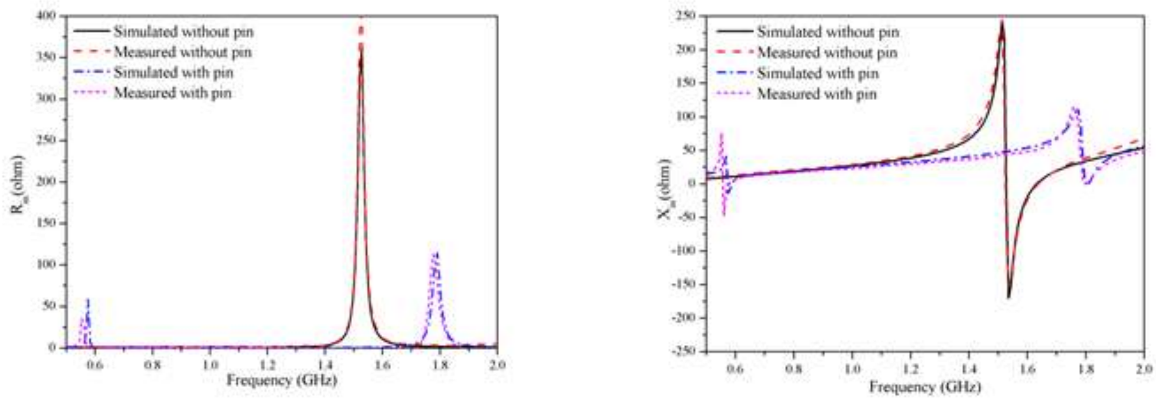


Fig. 8. Surface current distribution of microstrip edge fed single shorted RMSAat corresponding (a) F_L and (b) F_F



a) b)

Fig. 9. Comparison of (a) Input resistance and (b) Input reactance of microstrip fed RMSA

Fig.9a)andb)depictsthesimulatedandmeasuredresultsof inputresistanceandreactanceofmicrostripradiatingedgefed RMSA. Theinput impedance ofwithout andwithashorting pinof the RMSAhas reducedfrom370 Ω to 50 Ω at corresponding$F_F$of1.56GHzand1.8GHz,respectively.Fig.10showsthesimulatedandmeasuredradiationpatternof microstripradiating edgefedRMSAwithashorting postat d/w=0.1forF_F=1.8GHz. Thesimulated andmeasured gain of4.26dBiand3.15dBi,respectivelyisobtainedatF_F=1.8 GHzand1.802GHz.

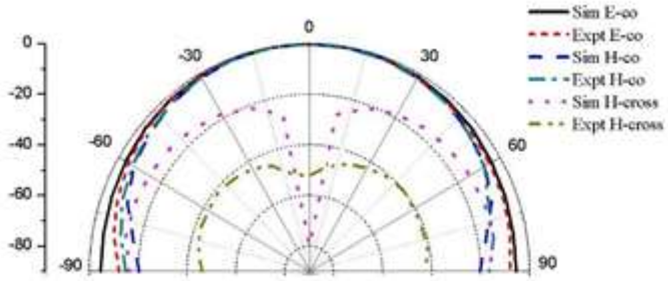


Fig. 10. Radiation pattern of microstrip edge fed RMSA with shorting pin at d/w= 0.1 for F_F= 1.8 GHz

V. Conclusion

Inthispaper,microstripfeedlineof50Ωimpedancehasbeenproposedtomatchtheimpedanceofradiatingedgefed RMSAusingashortingpost.Thismethodovercomesthedisadvantagesofusingquarterwavetransformerandinsetfedtechnique.Ithasbeenshownthattheradiatingedgeimpedance oftheMSAcanbeadjusted inawiderangebyselecting the shortingpostlocation.Ananalysisofthelowerandfundamentalmodecharacteristicsofshorted RMSAarealsopresented .Simulation andmeasuredresultsareinreasonable agreement.

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